Claims

I claim:

1. A method for canceling echo for a communications device comprising:

storing an existing filter coefficient set;

periodically calculating a trial filter coefficient set;

processing an echo-containing signal over a predetermined time period using the existing filter coefficient set to provide a first echo-canceled output signal;

processing the echo-containing signal over the predetermined time period using the trial filter coefficient set to provide a trial echo-canceled output signal;

calculating a first energy value of the first echo-canceled output over the predetermined time period;

calculating a trial energy value of the trial echo-canceled output over the predetermined time period;

determining if the echo-containing signal is dominated by echo; and

updating the existing filter coefficient set with the trial coefficient set where the echo-containing signal is dominated by echo and the trial energy is less than the first energy.

2. The method of claim 1 wherein the step of processing the echo-containing signal to provide the first echo-canceled output signal comprises:

filtering an echo-causing signal using the existing filter coefficient set to provide an estimate of the echo component; and

subtracting the estimate of the echo component from the echo-containing signal to provide the first echo-canceled output signal.

3. The method of claim 1 wherein the step of processing the echo-containing signal to provide the trial echo-canceled output signal comprises:

filtering an echo-causing signal using the trial filter coefficient set to provide an estimate of the echo component; and

subtracting the estimate of the echo component from the echo-containing signal to provide the trial echo-canceled output signal.

4. The method of claim 1 wherein the step of determining if the echo-containing signal is dominated by echo comprises:

capturing a predetermined number of samples of an echo-causing signal and the echo-containing signal over the predetermined time period;

calculating a correlation function between the echo-containing signal and the echo-causing signal over a correlation window;

calculating a first value using the correlation function over a portion of the correlation window where echo is expected;

calculating a second value using the correlation function over a portion of the correlation window where no echo is expected; and

computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

5. The method of claim 4 wherein the portion of the correlation window where no echo is expected is a last 1/2 of the correlation window, and the step of calculating the second value comprises calculating the second value from the last ½ of the correlation window.

6. The method of claim 4 wherein the portion of the correlation window where no echo is expected is a last 1/4 of the correlation window, and the step of calculating the second value comprises calculating the second value from the last 1/4 of the correlation window.

7. The method of claim 4 wherein the portion of the correlation window where echo is expected is a first 1/2 of the correlation window, and the step of calculating the first value comprises calculating the first value from the first 1/2 of the correlation window using the correlation function.

8. The method of claim 4 wherein the first value is a peak magnitude, and the step of calculating the peak magnitude comprises determining a maximum value of the correlation function during the potion of the correlation window where echo is expected.

9. The method of claim 4 wherein the second value is a baseline value, and the step of calculating the baseline value comprises calculating a Root Mean Square value of the correlation function over the portion of the correlation window where no echo is expected.

10. The method of claim 1 wherein the step of determining if the echo-containing signal is dominated by echo comprises:

capturing a predetermined number of samples of an echo-causing signal and the first echo-canceled output signal over the predetermined time period;

calculating a correlation function between the first echo-canceled output signal and the echo-causing signal over a correlation window;

calculating a first value using the correlation function over a portion of the correlation window where echo is expected;

calculating a second value using the correlation function over a portion of the correlation window where no echo is expected; and

computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

11. The method of claim 1 further comprising:

capturing a predetermined number of samples of an echo-causing signal and the echo-containing signal;

wherein the step of processing the echo-containing signal to provide the first echo-canceled output signal comprises processing the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the echo-containing signal, and providing a corresponding first echo-canceled output signal for each sample, and

the step of calculating the first energy value comprises summing the squares of the first echo-canceled output signal for each of the corresponding first echo-canceled output signal samples over the predetermined time period.

12. The method of claim 1 further comprising:

capturing a predetermined number of samples of an echo-causing signal and the echo-containing signal;

wherein the step of processing the echo-containing signal to provide the trial echo-canceled output signal comprises processing the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the echo-containing signal, and providing a corresponding trial echo-canceled output signal for each sample, and

the step of calculating the trial energy value comprises summing the squares of the trial echo-canceled output signal for each of the corresponding trial echo-canceled output signal samples over the correlation window.

13. The method of claim 1 further comprising:

capturing a predetermined number of samples of an echo-causing signal and the echo-containing signal;

wherein the step of processing the echo-containing signal to provide the trial echo-canceled output signal comprises processing the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the echo-containing signal using the trial filter coefficient set, and providing a corresponding trial echo-canceled output signal for each sample, and

modifying the trial filter coefficient set responsive to each sample of the corresponding trial echo-canceled output signal.

14. The method of claim 1 further comprising:

modifying the trial filter coefficient set after the predetermined time period.

15. The method of claim 1 further comprising:

selecting the trial echo-canceled output as an output where the echo-containing signal is dominated by echo and the trial energy is less than the first energy.

16. The method of claim 1 wherein the communications system is a cellular system utilizing a Time Division Multiple Access (TDMA) architecture, and the predetermined time period is a TDMA time frame.

17. A method for determining whether an echo-containing signal is dominated by echo comprising:

capturing a predetermined number of samples of an echo-causing signal and the echo-containing signal over a predetermined time period;

calculating a correlation function between the echo-containing signal and the echo-causing signal over a correlation window;

calculating a first value using the correlation function over a first portion of the correlation window where echo is expected;

calculating a second value using the correlation function over a second portion of the correlation window where no echo is expected; and

computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

18. The method of claim 17 wherein the portion of the correlation window where no echo is expected is a last 1/2 of the correlation window, and the step of calculating the second value comprises calculating the second value from the last 1/2 of the correlation window.

19. The method of claim 17 wherein the portion of the correlation window where no echo is expected is a last 1/4 of the correlation window, and the step of calculating the second value comprises calculating the second value from the last 1/4 of the correlation window.

20. The method of claim 17 wherein the portion of the correlation window where echo is expected is a first half of the correlation window, and the step of calculating the first value comprises calculating the first value from the first ½ of the correlation window using the correlation function.

21. The method of claim 17 wherein the first value is a peak magnitude, and the step of calculating the peak magnitude comprises determining a maximum value of the correlation function during the portion of the correlation window where echo is expected.

22. The method of claim 17 wherein the second value is a baseline value, and the step of calculating the baseline value comprises calculating a Root Mean Square value of the correlation function over the portion of the correlation window where no echo is expected.

23. The method of claim 17 wherein at least one of the first value and the second value used to compute the status indicator is proportional to an energy value of one of the first and second portions of the correlation window calculated by summing the squares of the correlation function over the one portion.

24. The method of claim 17 wherein at least one of the first value and the second value used to compute the status indicator is proportional to a norm of one of the first and second

portions of the correlation window calculated by taking the square root of the sum of the squares of the correlation function over the one portion.

25. An echo canceler for a communications system comprising:

an echo-containing signal input for receiving a signal;

an echo-causing signal source for developing an echo-causing signal;

a first filter coupled to the echo-containing signal input and the echo-causing signal source for processing the echo-containing signal over a predetermined time period using an existing filter coefficient set to provide a first echo-canceled output signal at a first filter output node;

a trial filter coupled to the echo-containing signal input and the echo-causing signal source for processing the echo-containing signal over a predetermined time period using a trial filter coefficient set to provide a trial echo-canceled output signal at a trial filter output node;

a controller coupled to the echo-containing signal input, the echo-causing signal source, the first filter output node, and the trial filter output node for periodically recalculating the trial coefficient set, calculating a first energy value of the first echo-canceled output signal over the predetermined time period, calculating a trial energy value of the trial echo-canceled output signal over the predetermined time period, determining if the echo-containing signal is dominated by echo, and updating the existing filter coefficient set with the trial coefficient set where the echo-containing signal is dominated by echo and the trial energy is less than the first energy.

26. The echo canceler of claim 25 further comprising a selector having first and second selector input nodes coupled to the first filter output node and the trial filter output node respectively, and having a selector output node for providing an echo-suppressed output signal, the

selector responsive to the controller for connecting the trial filter output node to the selector output node where the echo-containing signal is dominated by echo and the trial energy is less than the first energy.

27. The echo canceler of claim 25 wherein the first filter comprises:

a first Finite Impulse Response Filter (FIR) coupled to the echo-causing signal source and the controller, for filtering the echo-causing signal using the existing filter coefficient set to provide an estimate of the echo component at a first FIR output node; and

a first adder coupled to the first FIR output node and the echo-containing signal input and having a first adder output node wherein the first adder output node is the first filter output node, the first adder for subtracting the estimate of the echo component from the echo-containing signal to provide the first filter echo-canceled output at the first adder output node.

28. The echo canceler of claim 25 wherein the trial filter comprises:

a trial Finite Impulse Response Filter (FIR) coupled to the echo-causing signal source and the controller, for filtering the echo-causing signal using the trial filter coefficient set to provide an estimate of the echo component at a trial FIR output node; and

a trial adder coupled to the trial FIR output node and the echo-containing signal input and having a trial adder output node wherein the trial adder output node is the trial filter output node,

the trial adder for subtracting the estimate of the echo component from the echo-containing signal to provide the trial filter echo-canceled output at the trial adder output node.

29. The echo canceler of claim 25 wherein the first filter captures a predetermined number of samples of an echo-causing signal and the echo-containing signal and processes the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the echo-containing signal, and provides a corresponding first echo-canceled output signal for each sample, and

the controller includes a first energy calculator coupled to the first output filter node for calculating the first energy value by summing the squares of the first echo-canceled output signal for each of the corresponding first echo-canceled output signal samples over the predetermined time period.

30. The echo canceler of claim 29 wherein the predetermined number of samples is 160.

31. The echo canceler of claim 25 wherein the trial filter captures a predetermined number of samples of an echo-causing signal and the echo-containing signal and processes the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the

echo-containing signal, and provides a corresponding trial echo-canceled output signal for each sample, and

the controller includes a trial energy calculator coupled to the trial output filter node for calculating the trial energy value by summing the squares of the trial echo-canceled output signal for each of the corresponding trial echo-canceled output signal samples over the predetermined time period.

32. The echo suppresser of claim 25 wherein the controller includes an echo analyzer coupled to the echo-causing signal source and the echo-containing signal input for determining if the echo-containing signal is dominated by echo by capturing a predetermined number of samples of the echo-causing signal and the echo-containing signal over the predetermined time period, calculating a correlation function between the echo-containing signal and the echo-causing signal over a correlation window, calculating a first value using the correlation function over a portion of the correlation window where echo is expected, calculating a second value using the correlation function over a portion of the correlation window where no echo is expected, computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

33. The echo canceler of claim 32 wherein the portion of the correlation window where no echo is expected is a last 1/2of the correlation window, and the echo analyzer calculates the second value by calculating the second value from the last 1/2 of the correlation window.

34. The echo canceler of claim 32 wherein the portion of the correlation window where no echo is expected is a last 1/4 of the correlation window, and the echo analyzer calculates the second value by calculating the second value from the last 1/4 of the correlation window.

35. The echo canceler of claim 32 wherein the portion of the correlation window where echo is expected is a first ½ of the correlation window, and the echo analyzer calculates the first value by calculating the first value from the first ½ of the correlation window using the correlation function.

36. The echo canceler of claim 32 wherein the first value is a peak magnitude, and the echo analyzer calculates the peak magnitude by determining a maximum value of the correlation function during the potion of the correlation window where echo is expected.

37. The echo canceler of claim 32 wherein the second value is a baseline value, and the echo analyzer calculates the baseline value by calculating a Root Mean Square value of the correlation function over the portion of the correlation window where no echo is expected.

38. The echo canceler of claim 32 wherein the predetermined number of samples is 160.

39. The echo suppresser of claim 25 wherein the controller includes an echo analyzer coupled to the echo-causing signal source and the first filter output node for determining if the echo-containing signal is dominated by echo by capturing a predetermined number of samples of the echo-causing signal and the first echo-canceled output signal over the predetermined time period, calculating a correlation function between the first echo-canceled output signal and the echo-causing signal over a correlation window, calculating a first value using the correlation function over a portion of the correlation window where echo is expected, calculating a second value using the correlation function over a portion of the correlation window where no echo is expected, computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

40. The echo canceler of claim 25 wherein the trial filter captures a predetermined number of samples of an echo-causing signal and the echo-containing signal and filters the echo-containing signal for each of the predetermined number of samples of the echo-causing signal and the echo-containing signal, and provides a corresponding trial echo-canceled output signal for each sample, and

the controller modifies the trial coefficient set responsive to each sample of the corresponding trial echo-canceled output signal.

41. The echo canceler of claim 25 wherein the controller modifies the trial coefficient set after each predetermined time period.

42. The echo canceler of claim 25 wherein the communications system is a mobile communications system.

43. The echo canceler of claim 42 wherein the mobile communications system utilizes a Time Division Multiple Access (TDMA) architecture, and the predetermined time period is a TDMA time frame.

44. An echo analyzer for determining if an echo-containing signal is dominated by echo comprising:

a echo-containing signal input for receiving a signal;

an echo-causing signal source for developing an echo-causing signal; and

a controller operatively connected to the echo-containing signal input and the echo-causing signal source for capturing a predetermined number of samples of the echo-containing signal and the echo-causing signal over a predetermined time period, calculating a correlation function between the echo-containing signal and the echo-causing signal over a correlation window, calculating a first value using the correlation function over a portion of the correlation window where echo is expected, calculating a second value using the correlation function over a portion of the correlation window where no echo is expected, computing a status indicator as a function of the first value and the second value, the status indicator used for determining whether the echo-containing signal is dominated by echo.

45. The echo analyzer of claim 44 wherein the portion of the correlation window where no echo is expected is a last 1/2 of the correlation window, and the controller calculates the second value by calculating the second value from the last 1/2 of the correlation window.

46. The echo analyzer of claim 44 wherein the portion of the correlation window where no echo is expected is a last 1/4 of the correlation window, and the controller calculates the second value by calculating the second value from the last 1/4 of the correlation window.

47. The echo analyzer of claim 44 wherein the portion of the correlation window where echo is expected is a first 1/2 of the correlation window, and the controller calculates the first value by calculating the first value from the first 1/2 of the correlation window using the correlation function.

48. The echo analyzer of claim 44 wherein the first value is a peak magnitude, and the controller calculates the peak magnitude by determining a maximum value of the correlation function during the potion of the correlation window where echo is expected.

49. The echo analyzer of claim 44 wherein the second value is a baseline value, and the controller calculates the baseline value by calculating a Root Mean Square value of the correlation function over the portion of the correlation window where no echo is expected.

50. The echo canceler of claim 44 wherein the predetermined number of samples is 160.

51. The echo canceler of claim 44 wherein at least one of the first value and the second value used to compute the status indicator is proportional to an energy value of one of the first and second portions of the correlation window calculated by summing the squares of the correlation function over the one portion.

52. The echo canceler of claim 44 wherein at least one of the first value and the second value used to compute the status indicator is proportional to a norm of one of the first and second portions of the correlation window calculated by taking the square root of the sum of the squares of the correlation function over the one portion.